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Elective Change of Surgeon During the OR Day Has an Operationally Negligible Impact on Turnover Time

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Abstract

Study Objective—To compare turnover times for a series of elective cases with surgeons following themselves to turnover times for a series of previously scheduled, elective procedures where the following surgeon differed from the preceding surgeon. We also considered the effect of changing procedure types and the time of day on turnover time.

Design—Retrospective, cohort study.

Setting—University-affiliated teaching hospital.

Measurements—We used the operating room statistical database to gather 32 months of turnover data from a large academic institution. Turnover time data for the same-surgeon and surgeon-swap groups were batched by month to minimize autocorrelation and achieve data normalization. A two-way ANOVA using the monthly batched data was performed with surgeon swapping and changes in procedure category as variables of turnover time. Similar analyses were performed using individual surgical services and using hourly time intervals during the surgical day as additional covariates to surgeon swapping.

Main Results—The mean (95% confidence interval) same-surgeon turnover time was 43.6 (43.2 – 44.0) min versus 51.0 (50.5 – 51.6) min for a planned surgeon swap ($p < 0.0001$). This resulted in a difference (95% confidence interval) of 7.4 (6.8 – 8.1) min. The exact increase in turnover time was dependent on surgical service, change in subsequent procedure type, time of day when the turnover occurred, and turnover frequency per OR.

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CONFLICTS OF INTEREST: None

Conclusions—The investigated institution averages 2.5 cases per OR per day. The cumulative additional turnover time (far less than one hour per operating room per day) for switching surgeons definitely does not allow the addition of another elective procedure if the difference could be eliminated. A flexible scheduling policy allowing surgeon swapping rather than requiring full blocks incurs minimal additional staffed time during the OR day while allowing the schedule to be filled with available elective cases.

Keywords

Surgeon swapping; Turnover times; Operating room efficiency

Introduction

Block booking, wherein a surgeon is assigned the same operating room (OR) for all or part of a day, is commonly practiced to match available staffing to elective surgical demand while promoting high anesthesia productivity.^{1,2} Operating rooms can be conceptualized as workstations on a production line. In this paradigm, successive patients are the workpieces, and all of the OR team members (including the surgeon) are analogous to the tools whose actions bring about the patient's therapeutic encounter. Carrying this analogy further, changing tools in an industrial process frequently adds time without adding value. Does this part of the analogy extend to patient care? Does changing surgeons between electively scheduled cases systematically increase the time between cases, compared to cases in which the surgeon does not change? This question is illustrated in Figure 1.

Operating room managers understand that turnover time is required between cases to clean and prepare the OR. For convenience, most OR suites use a standard 'planned' turnover time, though more sophisticated methods to predict when cases will begin have been described.³ Under strictly controlled circumstances, constraining the OR team (nurses, anesthesia personnel, and surgeons) to work together for the entire day yields modest reductions in non-operative time intervals.⁴ Our question is not one of reducing or constraining turnover time, but rather: Does a planned swap of surgeons in the elective OR schedule prolong turnovers enough to warrant an adjustment in the allotted turnover time when constructing the schedule?

Changing surgeons may increase the time between cases if instrumentation changes, requiring extra setup time. Similarly, if the case type changes significantly (orthopedics followed by thoracic, for example), the team may need extra time to prepare for the case. Hence, scheduled changes of surgeons might increase turnover. When changes in the sequence of cases are unscheduled (moving a case from one OR to another on the day of surgery to minimize over-utilized time, for example), survey data from OR managers indicates that such a move must save one hour, on average, to justify the effort of moving the case.⁵ Thus, for day-of-surgery case movements, an aggregated time penalty for swapping surgeons is perceived to be one hour (although some OR managers will be more willing to accept 'risk' in scheduling than others). Appreciating a penalty for moving cases on the day of surgery is not altogether surprising, given the last minute preparations, changes in expectations, etc., that must be managed when moving a case. On the other hand,

when the schedule is planned in advance to have surgeons change between cases, the rest of the OR team has prior knowledge and time to plan for the change of personnel, and might be able to do this without added turnover time.

We know from prior work that OR start time tardiness is not significantly affected by scheduled surgeon changes.⁶ Also, this practice should not affect the preparatory work pace of the OR staff by increasing their workday, as the length of the day is known in advance since the cases are already scheduled.⁷ Moreover, others have shown that overall OR work load has minimal impact on work velocity.⁷ By these lines of reasoning, turnover times between cases with different surgeons should (or at least could) be no different than turnover times for the same surgeon following themselves.

This question is relevant because if the time penalty for switching surgeons during the workday is large, there would be an additional incentive to entice surgeons to book full days or blocks of their own cases in order to maximize the productivity of other OR personnel, or to estimate and build in added turnover time for swap cases when planning staffing.

Therefore, we set out to answer a single simple question: what is the turnover time penalty, if any, for allowing elective surgeon swaps between cases looking at the actual schedule in a large OR suite?

Materials and Methods

This study was approved by the Partners Healthcare System IRB (Boston, MA). We queried the OR statistics database for all turnover times in the period 10/01/04 to 6/30/07. The study was conducted in the main OR suite (50 operating rooms) of a large academic medical center. The medical center had high operating room utilization, and many rooms ran up to or beyond the scheduled end-of-block time. It was routine practice for the circulating nurse to call the following surgeon at the beginning of wound closure for the current case if there was a planned surgeon swap. However, execution of this step was not documented and so is not available for review. Surgeons only operated at the study hospital, but they could be engaged in many activities on OR days, including making rounds and seeing patients in clinic. All such activities occurred within the confines of one large interconnected building complex.

Each turnover was categorized as a same-surgeon turnover (same surgeon following themselves), or as a different-surgeon turnover (planned change of surgeons between cases). Cases & turnovers were only included if the actual sequence of cases performed matched the planned sequence of cases on the elective OR schedule, as finalized in the afternoon of the previous workday. In other words, we only analyzed sequences of cases where the actuality followed the electively planned sequence.

Turnover time (TOT) was defined as the time from when the previous patient left the OR until the subsequent patient entered the OR. Turnovers of more than 90 minutes were considered planned gaps between cases and excluded.⁸

Turnovers involving surgeons from different services were rare, but were not excluded. Thus, the comparison was usually between turnovers with the same surgeon following

themselves vs. turnovers with two different surgeons from the same surgical service. When a turnover occurred that included a change in service, that turnover was attributed to the following service, using the assumption that most of the turnover time would be consumed by setting up for the subsequent case.

To account for the impact of differing procedure categories on turnover time, clinical classification software (CCS) procedure codes were obtained for each of the cases. Each turnover was either classified as same-CCS (similar codes for sequential cases) or different-CCS (dissimilar codes for consecutive cases). In the case of procedures with multiple CCS codes, these procedures were listed as different-CCS unless all of the codes matched for the successive surgery.

All statistical analyses were performed using SAS software (version 9.3, SAS Institute, Inc., Cary, NC). The Runs test was used to detect the presence of autocorrelation among turnovers sorted by the date and time at which each turnover began. To eliminate the effect of autocorrelation between turnovers, batch methods were used for analysis.⁹ After batching, the Shapiro-Wilk test was used to test for normality of distributions. Univariate analysis of turnover time based on same surgeon versus surgeon swapping between cases was performed using the Student's t-test. To further analyze the effect of procedure uniformity and swapping surgeons on turnover time, a two-way unbalanced ANOVA with Tukey-Kramer post hoc analysis was then performed on CCS change, surgeon swapping, and their interaction. A similar method was utilized to analyze the effects of individual surgical services and surgeon swapping on turnover time. This manner of analysis was also performed to test the effects of time of day and surgeon swapping on turnover time. Hourly periods were analyzed, except that we created two composite intervals: midnight to 10:59 AM, and 8:00PM to 11:59PM, during which there were few turnovers. These two time periods were formed to increase the sample sizes (turnovers) of these groups. Lastly, turnover frequency per OR was similarly analyzed, with turnover frequency being grouped as follows: 1–2, 3–4, and greater than four cases per OR per day. Confidence intervals of the group means and differences were produced based on a normal distribution after testing for normality and Tukey-Kramer correction as applicable. $P = 0.05$ was considered statistically significant.

Results

There were 52,036 elective cases in the dataset. These included 20,963 same-surgeon turnovers and 4,818 different-surgeon turnovers that were planned as part of the elective schedule.

Exploratory examination of the data revealed that the turnover time distributions were right-skewed and approximated graphically as log-normal distributions (Figure 2). Moreover, there was significant positive serial correlation from one turnover to the next turnover during the day (Runs test, $p < 0.0001$). Averaging turnover time data points over monthly periods was sufficient to eliminate this autocorrelation ($p = 0.16$, $n = 33$ months). Also, batching by month resulted in normalized data (Shapiro-Wilk test, $p = 0.73$, Figure 3).

The overall mean (95% confidence interval) turnover time for the same surgeon following themselves was 43.6 (43.2 – 44.0) min versus 51.0 (50.5 – 51.6) min ($p < 0.0001$) for turnovers where surgeons swapped between cases with a difference (95% confidence interval) of 7.4 (6.8 – 8.1) min. There was not a statistically significant main effect for CCS change on turnover time, but there was a significant interaction effect ($p < 0.0001$). Post-hoc analyses indicated that changing CCS codes between cases was associated with greater turnover times when surgeons were swapped (Table 1). Turnover times for swapped cases were slightly but statistically significantly increased for 9 out of the 13 major surgical services (Table 2) and at all time periods and turnover frequencies tested (Tables 3 and 4).

Discussion

The impact of switching surgeons is statistically significant, but relatively small (< 15 minutes) in the context of our (typically) 600 minute OR day accommodating 2 or 3 cases in the allotted time. Eliminating this added time by constraining block booking to same surgeon following themselves would have little operational utility. For example, our hospital could not reliably add another case to that operating room by saving the added turnover time.¹⁰

There are several potential reasons for the longer TOT when changing surgeons between cases. For example, communication about instrumentation needs for the subsequent case may be limited when switching surgeons, consequently increasing rework during turnover. The prior case may finish early, and the following surgeon may be unavailable until the scheduled time or simply unaware of the early finish. Finally, the following surgeon may themselves be delayed and hence unavailable. All of these issues may, in principle, be minimized by improving communications between OR team members.¹¹ However, the data in our study were gathered prior to the development of methods to better predict the finish times of surgeries¹² or to communicate with people outside the operating room using mobile devices or text notifications.¹³ Even without these technologies, the added time between cases was only about 10 minutes, on average, despite relying solely on the nurse to call or page the following surgeon when the prior case was ending. Thus, in this general OR setting, the reductions in turnover time gained by better end time prediction or better communication technologies are likely to be small. This stands in contrast to ‘focused factory’ designs wherein perioperative systems have been engineered to maximize throughput of relatively short cases. Even in such a setting, saving the 10 to 15 minutes imposed by changing surgeons, supposing changing to a different surgeon midway through a 5-case list, is not sufficient to add another case, nor would the penalty of changing surgeons force the list to be shortened.

One could construe the additional TOT as the cost of switching surgeons rather than filling the schedule with full-day blocks of a single surgeon’s cases. However, this is only occasionally correct. Close to the date of surgery, i.e., during the few days in which the schedule is set up, staffing has been planned and staffing costs have been committed.^{5,14} Thus, the additional TOT only leads to additional cost if it causes the room to run past its scheduled end time to such a degree that overtime must be paid.

This study is limited in that it is a retrospective analysis of data presented from one medical center. Retrospective analyses are vulnerable to uncontrolled variability among the studied populations that may not be accounted for in our analyses despite the large sample sizes that were employed. On the other hand, the data were process times, rather than medical outcomes, and it is difficult to envision a prospective randomized study of the entire throughput of an OR suite that could be later generalized to the general operation of a hospital. In addition, this analysis was based on the caseload of a large academic center with a disproportionate balance of lengthy surgeries. Our finding that the relatively small added time for a planned change of surgeon between elective cases is not worth trying to control (from an operational sense, at least) might not apply to outpatient surgical centers with shorter cases and turnover times.

If the operational impact of changing surgeons in the middle of a planned OR day is small, what about the impact on other clients of the system? Surgeons and anesthesiologists are not good judges of whether turnovers are prolonged or not, so they may be unaware of any actual prolongation in turnover time. Patients may also be aware of deviations from scheduled start times. For example, in analyses of patient complaint data, a 1-hour change in the actual minus scheduled start times was associated with increased likelihood of a subsequent complaint about anesthesia services during a follow-up phone call eliciting feedback about the anesthesia experience. Again, the likely added time from a planned change of surgeon is less than this interval, suggesting that changing surgeons during the OR day is unlikely to impact patient satisfaction.

It will never be practical to achieve 100% single-surgeon block booking. However, increased TOT due to surgeon switching is small, and scheduling / staff planning can be adjusted to allow for it. The institutional benefit of the additional throughput far outweighs the small delay incurred by a different surgeon following in a block rather than leaving allocated block time empty.

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Comparison: **VS.** **Is $(\text{Turnover } 1 \rightarrow 1) = (\text{Turnover } 1 \rightarrow 2)$?****Figure 1.**

Graphic illustration of the study question to be addressed.

Figure 2.

Distributions of turnover times (bars) with kernel density estimation (red line) and the log-normal distribution approximation (blue line).

Top panel: Same surgeon following themselves; Bottom panel: Turnovers between different surgeons.

Figure 3.

Distributions of turnover times (bars) with kernel density estimation (red line) and the normal distribution approximation (blue line) after batching by month.

Top panel: Same surgeon following themselves; Bottom panel: Turnovers between different surgeons.

Table 1

Turnover Times by Swap and CCS

	Following Self (min) Mean ± 95%CI	N	Surgeon Swap (min) Mean ± 95%CI	N	Difference (min) Mean ± 95%CI	p *
No CCS Change	44.5 (43.9 – 45.1)	9408	48.6 (47.4 – 49.8)	672	4.1 (2.9 – 5.3)	<0.0001
CCS Change	42.8 (42.5 – 43.2)	11554	51.4 (50.8 – 52.0)	4146	8.6 (7.4 – 9.8)	<0.0001

Turnover times and number of cases (N), batched into 33 monthly groups, for comparisons between same surgeon following themselves vs. electively planned swap of surgeons during the work day and between cases having similar CCS codes vs. differing CCS codes.

* P value computed using 2-way ANOVA with post hoc Tukey-Kramer adjustment on monthly batched data. Swap main effect and swap CCS interaction were both significant ($p < 0.0001$) while CCS main effect was not significant.

Abbreviations: CI; confidence interval, CCS; clinical classification software procedure code.

Table 2

Turnover Times by Swap and Service

Service	Following Self (min) Mean $\pm$ 95%CI	N	Surgeon Swap (min) Mean $\pm$ 95%CI	N	Difference (min) Mean $\pm$ 95%CI	p *
Emergency Surgery	47.1 (45.7 – 48.5)	704	44.8 (42.6 – 47.1)	209	-2.3 (-5.7 – 1.1)	NS
General Surgery	42.3 (41.7 – 42.9)	2598	52.6 (51.0 – 54.2)	300	10.3 (6.9 – 13.7)	<0.0001
Gyn Surgery	43.0 (42.1 – 43.8)	1637	50.9 (49.4 – 52.4)	512	7.9 (4.6 – 11.3)	<0.0001
Neurosurgery	52.8 (51.9 – 53.7)	1278	58.9 (56.5 – 61.2)	246	6.1 (2.7 – 9.4)	<0.0001
OMF	45.8 (44.2 – 47.5)	375	49.0 (46.0 – 52.0)	178	3.2 (-0.2 – 6.6)	NS
Orthopedics	51.0 (50.3 – 51.7)	3991	56.8 (55.6 – 58.0)	636	5.8 (2.5 – 9.2)	<0.0001
Pediatrics	33.0 (32.1 – 33.9)	1618	42.6 (41.1 – 44.1)	305	9.6 (6.3 – 13.0)	<0.0001
Plastic Surgery	44.9 (43.5 – 46.2)	504	50.3 (48.4 – 52.3)	225	5.4 (2.0 – 8.8)	<0.0001
Surgical Onc	45.1 (43.6 – 46.6)	930	54.2 (52.9 – 55.5)	281	9.1 (5.7 – 12.4)	<0.0001
Thoracic	49.3 (48.1 – 50.4)	1584	50.6 (48.4 – 52.8)	566	1.3 (-2.1 – 4.7)	NS
Transplant	54.2 (51.3 – 57.0)	222	54.9 (52.9 – 56.9)	257	0.7 (-2.7 – 4.1)	NS
Urology	35.3 (34.6 – 35.9)	3503	46.9 (45.1 – 48.8)	636	11.6 (8.3 – 15.0)	<0.0001
Vascular	40.7 (39.1 – 42.4)	1078	51.0 (48.9 – 53.0)	352	10.3 (6.9 – 13.7)	<0.0001

Turnover times and number of cases (N), batched into 33 monthly groups, for comparisons between same surgeon following themselves vs. electively planned swap of surgeons during the work day.

* P value computed using 2-way ANOVA with post hoc Tukey-Kramer adjustment on monthly batched data. Main effects and interaction were both significant ($p < 0.0001$).

Abbreviations: CI; confidence interval.

Table 3

Turnover Times by Swap and Time of the Day

Time	Following Self (min) Mean $\pm$ 95%CI	N	Surgeon Swap (min) Mean $\pm$ 95%CI	N	Difference (min) Mean $\pm$ 95%CI	p *
00:00–10:59	31.2 (30.4 – 32.0)	1338	39.3 (37.4 – 41.1)	178	7.1 (4.4 – 9.8)	<0.0001
11:00–11:59	35.8 (35.0 – 36.6)	1636	45.2 (42.4 – 48.0)	243	9.4 (6.7 – 12.0)	<0.05
12:00–12:59	39.2 (38.3 – 40.0)	2097	47.5 (45.7 – 49.3)	406	8.3 (5.7 – 11.0)	<0.0001
13:00–13:59	42.2 (41.6 – 42.8)	2511	49.6 (48.1 – 51.1)	533	7.4 (4.7 – 10.0)	<0.0001
14:00–14:59	45.4 (44.6 – 46.2)	2553	51.1 (49.5 – 52.8)	740	5.7 (3.1 – 8.4)	<0.01
15:00–15:59	45.9 (45.2 – 46.5)	2746	51.8 (50.5 – 53.0)	687	5.9 (3.2 – 8.5)	<0.0001
16:00–16:59	46.1 (45.5 – 46.7)	2897	53.8 (52.7 – 55.0)	691	7.7 (5.1 – 10.4)	<0.0001
17:00–17:59	47.5 (46.8 – 48.2)	2374	52.5 (51.3 – 53.7)	568	5.0 (2.3 – 7.7)	<0.05
18:00–18:59	48.7 (47.5 – 49.8)	1443	54.7 (52.9 – 56.6)	374	6.0 (3.4 – 8.8)	<0.0001
19:00–23:59	48.6 (47.4 – 49.8)	1367	55.7 (53.7 – 58.1)	345	7.1 (4.4 – 9.8)	<0.0001

Turnover times and number of cases (N), batched into 33 monthly groups, for comparisons between same surgeon following themselves vs. electively planned swap of surgeons during the work day.

* P value computed using 2-way ANOVA with post hoc Tukey-Kramer adjustment on monthly batched data. Main effects and interaction were both significant ($p < 0.0001$).

Abbreviations: CI; confidence interval.

Table 4

Turnover Times by Swap and Cases in Operating Room per Day

Cases per Day	Following Self (min)		N	Surgeon Swap (min)		N	Difference (min)		p *
	Mean	± 95%CI		Mean	± 95%CI		Mean	± 95%CI	
1 – 2	49.8	(49.3 – 50.3)	8235	53.9	(53.2 – 54.7)	2323	4.1	(2.2 – 6.2)	<0.0001
3 – 4	41.6	(41.3 – 42.0)	10419	48.8	(48.0 – 49.5)	2229	7.2	(5.1 – 9.2)	<0.0001
5	30.3	(29.6 – 31.0)	2308	43.1	(40.7 – 46.7)	266	12.8	(10.8 – 14.9)	<0.0001

Turnover times and number of cases (N), batched into 33 monthly groups, for comparisons between same surgeon following themselves vs. electively planned swap of surgeons during the work day.

* P value computed using 2-way ANOVA with post hoc Tukey-Kramer adjustment on monthly batched data. Main effects and interaction were both significant ($p < 0.0001$).

Abbreviations: CI; confidence interval.